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Pacific Northwest Region

SYMPTOM EVALUATION OF CONIFERS INFECTED WITH ROOT DISEASE IN A PROPOSED SEED ORCHARD AND EVALUATION PLANTATION SITE ON THE TIETON RANGER DISTRICT WENATCHEE NATIONAL FOREST, WASHINGTON

SYMPTOM EVALUATION OF CONIFERS INFECTED WITH ROOT DISEASES IN A PROPOSED SEED ORCHARD AND EVALUATION PLANTATION SITE ON THE TIETON RANGER DISTRICT, WENATCHEE NATIONAL FOREST, WASHINGTON

by

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ABSTRACT

A 23-acre proposed Douglas-fir seed orchard and evaluation plantation site was examined prior to tree felling and land clearing to evaluate symptom expression in four species of conifers (Douglas-fir, grand fir, ponderosa pine, and western larch) infected with root diseases. About one-third of the trees examined were infected by one or more of three principal root pathogens: *Phellinus weirii, Armillaria mellea,* and *Fomes annosus*. Crown symptoms and root collar symptoms were accurate indicators of 58.8% of the root-infected trees. Following tree harvesting, symptoms in freshly-cut stump surfaces were reliable indicators to detect 72.5% of root-infected trees. Surveys designed to record crown symptoms and root collar symptoms will give accurate estimates of the extent of mortality and imminent mortality due to root diseases. However, examination of freshly-cut stump surfaces will detect more accurately the total extent of root-infected trees.

INTRODUCTION

On August 23, 1979, a 23-acre proposed seed production and evaluation plantation site (Figure 1) was surveyed for root diseases (see Seed Production and Evaluation Plantation Site Evaluation, Tieton Ranger District by Filip, September 11, 1979). Most of the trees on the site had been logged in 1972, but some grand fir, Douglas-fir, ponderosa pine, and western larch remained. Some of the grand fir was dead and infected with *Phellinus weirii,* causal agent of laminated root rot. Because Douglas-fir was to be planted and is highly susceptible to laminated root rot (Hadfield and Johnson 1977), it was recommended that all stumps on the site be excavated to remove potential sources of infection. Several stumps also had decay caused by *Fomes annosus*. This disease, too, can be controlled by stump removal.

Fomes annosus and *A. mellea* very commonly infect or further colonize stumps after tree harvesting. *Fomes annosus* spreads long distances by airborne spores that infect freshly cut wood surfaces such as stump tops. Grand fir is particularly susceptible. Some spread by *F. annosus* occurs underground by root contacts. *Armillaria mellea* spreads almost exclusively underground by root contacts and black, infective structures called rhizomorphs. Also, liv

trees commonly have minor infections of *A. mellea* that become activated and colonize the remaining root system after the tree has been harvested. *Phellinus weirii* does not infect nor further colonize root systems of harvested old-growth trees in West Side Douglas-fir (Hansen 1979). This is probably true for other tree species but it has not been studied.

On October 8, 1980, the Tieton Ranger District began stump removal operations. Forest Pest Management pathologists saw this as an opportunity to observe incidence of infection on entire root systems of excavated East Side conifer species and relate this to above-ground symptoms of root diseases such as pre-harvest crown condition, root collar condition, and condition of stump surfaces. Little is known concerning symptom expression in East Side conifers infected with root pathogens. Such an evaluation might improve our ability to estimate extent of root diseases from above-ground characteristics on similarly affected sites.

OBJECTIVES

Objectives of this evaluation were:

(1) to determine what type of symptoms at the crown, root collar, and freshly-cut stump surface are associated with diseased root systems of four East Side conifer species;

(2) to verify by total root excavation and examination of as many stumps as possible the need to remove all stumps because of the suspected widespread occurrence of infected stumps.

METHODS

As many of the remaining trees as possible were examined on the site. Each tree was classified by species and crown condition. Crowns were rated on a scale of one to four, one being a healthy full crown and four being a severely symptomatic or dead tree (Fig. 2). Root collars were examined by excavating soil from around the root collar and one or two major lateral roots. Area around the root collar was examined for ectotrophic mycelium of *Phellinus weirii*. Root bark was removed to detect mycelial fans of *Armillaria mellea* (Fig. 3). Root wood was dissected to examine for laminated decay and setal hyphae caused by *P. weirii*, yellow wet stringy decay caused by *A. mellea*, or white stringy decay caused by *Fomes annosus*. Each tree was marked with a numbered metal tag as close to the ground line as possible.

Less than 1 week following harvesting of all standing trees, the stump surface of each tree was examined for presence of stain or decay (Fig. 4). No attempt was made to measure the amount of stain or decay. Cause of the decay was recorded. Trees were recorded by number if they had been tagged previously; otherwise new tags were attached. Stump surfaces of trees harvested in 1972 were not examined because they were covered with a hard layer of volcanic ash from the May 18, 1980 eruption of Mount St. Helens.

All stumps on the site were excavated with a D-8 bulldozer (Fig. 5). Metal tags were read before stumps were pushed out, since tags often became buried after stumps were excavated. The entire root system was examined for decay and recorded by root pathogen and percentage of root system decayed. Occasionally, decayed wood was collected and cultured on agar media to positively identify root pathogens.

RESULTS AND DISCUSSION

Forty-two of the remaining standing trees were examined for crown condition and root collar condition on the site. Most of the standing trees examined were either grand fir or Douglas-fir, however, some ponderosa pine and western larch were inspected.

Three root pathogens; *Phellinus weirii, Armillaria mellea,* and *Fomes annosus* were found causing infection in excavated root systems (Table 1). *Fomes annosus* was found only on grand fir, and six infected trees were dead. *Armillaria mellea* and *P. weirii* were found on all species except western larch. One dead grand fir was infected by *P. weirii* and another by *P. weirii* and *A. mellea* on the same tree. No dead Douglas-fir, ponderosa pine, or western larch were found.

Nearly one-third of all excavated stumps examined had infected roots (Table 1), and this may be an underestimation of the total percentage of infected stumps on the site. Although stumps of trees harvested in 1972 were not examined extensively, they appeared to have a higher incidence of root infection than stumps of recently harvested trees.

In the group of trees with completely healthy root systems as determined after stump excavation, 73.1% had healthy crowns or only slight crown abnormalities (rating 1 or 2), while 26.9% had thin, ragged, chlorotic, or dead crowns (rating 3 or 4), much of which was due to dwarf mistletoe in Douglas-fir and western larch (Table 2). All of the trees with totally healthy root systems had no root collar symptoms (Table 3).

In the group of trees with infected root systems, 41.2% had healthy crowns and no root collar symptoms, while 58.8% had symptomatic crowns and root collar symptoms (Tables 2 and 3). Grand fir was the only species that showed symptomatic crowns and root collar symptoms. Ten of the symptomatic grand firs averaged 91% infection of their root systems. Infected Douglas-fir, ponderosa pine, and one grand fir with no crown symptoms or root collar symptoms had an average of 25%, 6%, and 33%, respectively, of their root systems infected. Perhaps, if more of the root systems of Douglas-fir or ponderosa pine were infected, these species also would have shown symptomatic crowns or root collar symptoms.

The stump surfaces of 128 recently harvested trees were examined for stain or decay. In Douglas-fir, ponderosa pine, and western larch with completely healthy root systems, no stain or decay was found on the stump surfaces (Table 4). In grand fir, one-third of the trees with healthy root systems had stain at the stump surface. Much of this was probably "wetwood" which is caused by bacteria rather than pathogenic fungi. Wetwood and stain are difficult to distinguish from each other in the field.

No stain or decay was found on fresh stump surfaces of Douglas-fir and ponderosa pine with root infections averaging 19% and 6%, respectively (Table 4). Grand fir was the only species with stain found at the stump surface. Decay was found at the stump surfaces of infected grand fir, Douglas-fir, and ponderosa pine when 96%, 37%, and 50%, respectively, of the root systems were infected. The appearance of decay at the stump surface was correlated highly

with percent of root systems infected, decay appearing when at least 37% of the root system was infected. No root infection was found in western larch, but only a small number of root systems was examined.

CONCLUSIONS AND RECOMMENDATIONS

Crown symptoms and root collar symptoms can be used to give accurate estimates of the extent of mortality and imminent mortality due to root diseases, especially in stands with a heavy component of grand fir. However, the total extent of root infection is underestimated if crown symptoms or root collar symptoms alone are relied upon, particularly in trees that have less than one-third of their root systems infected. A better estimate of the extent of trees with root infections (nearly 75% of infected trees) on a site can be obtained by examining the cut surface of recently harvested trees for stain or decay. However, trees with less than a quarter of their root systems infected may not even show stain or decay at the stump surface.

The September 11, 1979 recommendation to remove stumps from this proposed seed orchard and evaluation plantation site was justified since at least one-third of the stumps that were examined were infected. Over a third of the infections were *P. weirii*, which can cause substantial losses in Douglas-fir, the species to be planted on the site. Although *F. annosus* was associated with several dead grand fir, none was found on Douglas-fir, and therefore, *F. annosus* should not be a problem. Stump removal should control this pathogen also. *Armillaria mellea* has the potential to cause mortality in precommercial size Douglas-fir (Filip and Goheen 1978). However, no dead trees on the site were colonized by *A. mellea*. Armillaria root rot probably will be a problem only in Douglas-firs that are stressed by other factors.

It is recommended that future seed orchard or evaluation plantation sites having trees with crown symptoms, root collar symptoms, or recently cut stumps with stain or decay be further evaluated for extent of root diseases. The presence of root diseases may require that stumps be excavated before the site can be planted safely.

The information and recommendations presented in this report have been specifically formulated for the area we examined. Although some of this information may be applied to other areas experiencing similar root disease problems, these areas may differ sufficiently from the area we surveyed to warrant a separate biological evaluation to formulate specific recommendations. Forest Pest Management pathologists encourage and are available to perform such evaluations at the request of land managers.

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Table 1--Incidence of Principal Root Pathogens Found on Excavated Stumps By Tree Species

Tree Species	Total Number Examined	Total Number Infected	Root Pathogens Present					
			Fomes annosus	*Armillaria mellea*	*Phellinus weirii*	*Armillaria* + *Fomes*	*Phellinus* + *Fomes*	*Phellinus* + *Armillaria*
	Number of Stumps							
Grand fir	57	30	11	7	7	3	1	1
Douglas-fir	43	7	0	2	5	0	0	0
Ponderosa pine	22	3	0	2	1	0	0	0
Western larch	6	0	0	0	0	0	0	0
Total	128	40	11	11	13	3	1	1
Percent		31.3	27.5	27.5	32.5	7.5	2.5	2.5

Table 2--Relationship Between Crown Condition and Condition of Root Systems by Tree Species

Tree Species	Trees with healthy root systems: Total Number Examined	Crown Symptoms Rating 3-4	No Crown Symptoms Rating 1-2	Trees with infected root systems: Total Number Examined	Crown Symptoms Rating 3-4	No Crown Symptoms Rating 1-2
	----------Number of Trees----------					
Grand fir	3	0	3	11	10(91)[a]	1(33)
Douglas-fir	13	3[b]	10	4	0	4(25)
Ponderosa pine	4	0	4	2	0	2(6)
Western larch	6	4[b]	2	0	0	0
Total	26	7	19	17	10	7
Percent		26.9	73.1		58.8	41.2

a/ Number in parenthesis is mean percent of root system infected
b/ These trees had severe dwarf mistletoe infections

Table 3--Relationship Between Root Collar Condition and Condition of Root Systems by Tree Species

Tree Species	Trees with healthy root systems: Total Number Examined	Root Collar Symptoms	No Root Collar Symptoms	Trees with infected root systems: Total Number Examined	Root Collar Symptoms	No Root Collar Symptoms
	----------Number of Trees----------					
Grand fir	3	0	3	11	10(91)[a]	1(33)
Douglas-fir	13	0	13	4	0	4(25)
Ponderosa pine	4	0	4	2	0	2(6)
Western larch	6	0	6	0	0	0
Total	26	0	26	17	10	7
Percent		0	100.0		58.8	41.2

a/ Number in parenthesis is mean percent of root system infected

Table 4--Relationship Between Stump Surface Condition and Condition of Root Systems by Tree Species

Tree Species	Trees with healthy root systems: Total Number Examined	Stump Surface With: No Stain or Decay	Stain	Decay	Trees with infected root systems: Total Number Examined	Stump Surface With: No Stain or Decay	Stain	Decay
	----------Number of Stumps----------							
Grand fir	27	18	9[b]	0	30	5(35)[a]	13(45)	12(96)
Douglas-fir	36	36	0	0	7	4(19)	0	3(37)
Ponderosa pine	19	19	0	0	3	2(6)	0	1(50)
Western larch	6	6	0	0	0	0	0	0
Total	88	79	9	0	40	11	13	16
Percent		89.8	10.2	0		27.5	32.5	40.0

a/ Number in parenthesis is mean percent of root system infected
b/ Wetwood caused by bacteria

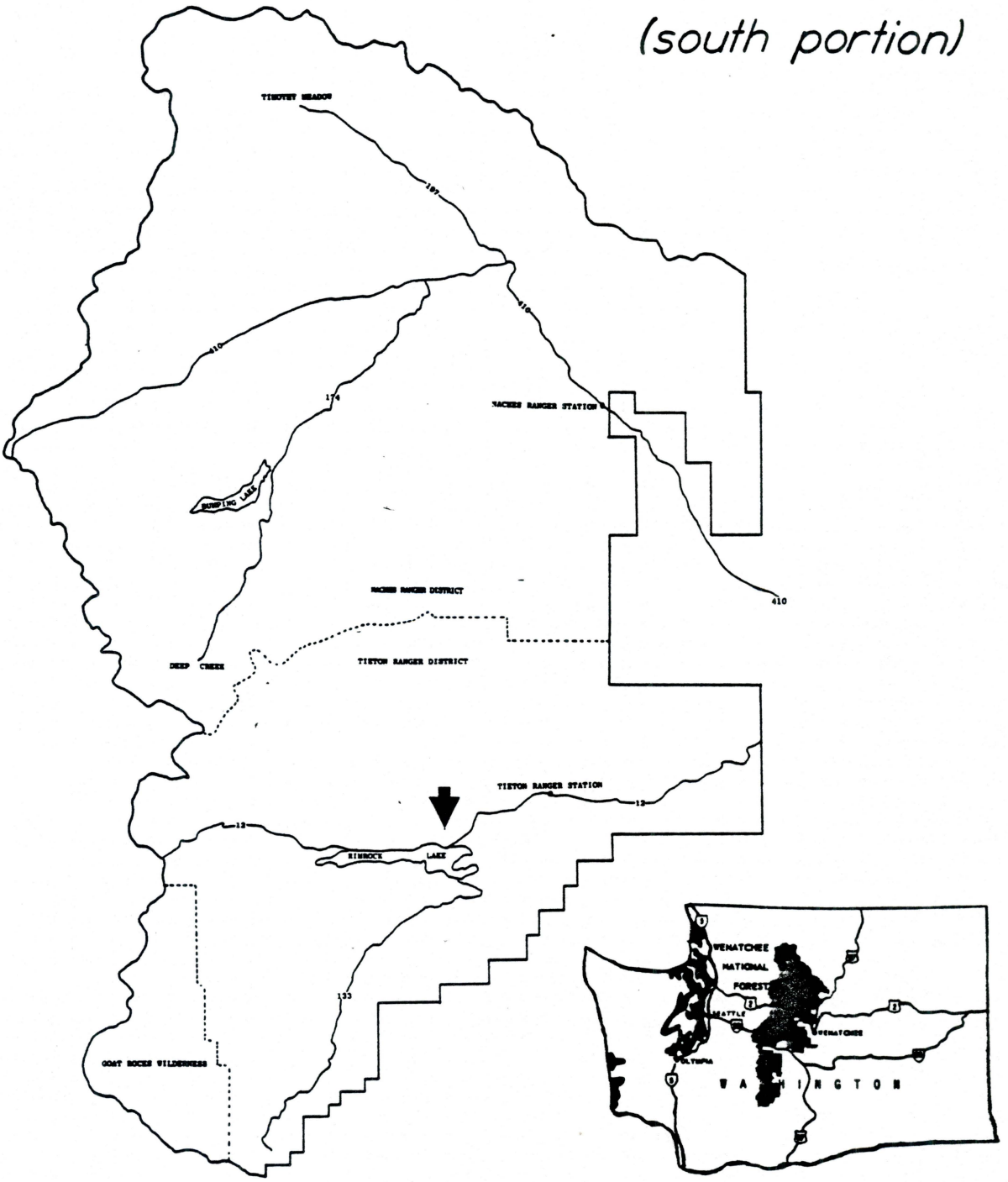

Fig.1--Map depicting location (arrow) of seed orchard and evaluation plantation that was surveyed.

Fig. 2--Crown symptoms such as these were used to detect about 60% of the infected trees on the site.

Fig. 3--Root collar symptoms as shown here were used to detect about 60% of the infected trees on the site. Tree here is infected by *Armillaria mellea*.

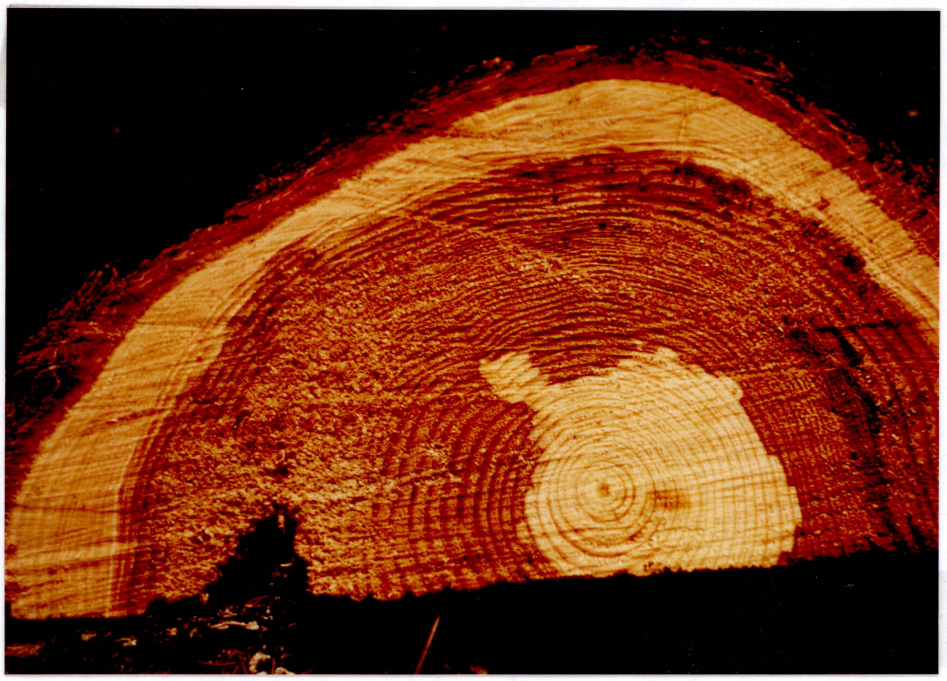

Fig. 4--Condition of freshly-cut stump surfaces was used to detect about 73% of the infected trees on the site. Decay here is caused by *Phellinus weirii*.

Fig. 5--Root systems of all trees examined were excavated totally by bulldozer to determine actual extent of root infection.